IV. REMARKS

The key benefits of the present invention variable pressure epitaxy system lie in the ability to (a) produce compositional grading within layers and (b) produce a series of two or more layers of a different composition, both in a precise and controllable manner. Two independent claims are now directed to these two embodiments.

The first embodiment is based on present claim 1, with the addition of an explicit recital in paragraphs (i) and (ii) that the first layer is an epitaxial layer and adding a requirement in paragraph (ii) for compositionally grading the first epitaxial layer by varying the pressure in the chamber to change the degree of supersaturation of the first growth solution during epitaxial growth. Basis for these changes that are in paragraph (ii) are at page 3, lines 31 to 33, page 6, line 20, page 7, lines 8 to 10, and page 7, line 29, as well as the entire discussion of Figure 2 from page 6, line 19, to page 7, line 33, in the description.

Embodiment (b) is illustrated in Figure 1 and discussed at page 5, line 3, to page 6, line 18. Covering this embodiment is second independent claim 13. It is based largely on present claim 12 with explicit requirement of varying the pressure between growth of the layers.

Both independent claims use the concept of varying pressure to modify the composition of an epitaxial layer. Embodiment (a) does this by varying the composition within a single layer and embodiment (b) does it by varying the composition between layers.

As explained in the specification, the inventors have devised a method for growing semiconductor epitaxial layers in which they deliberately vary the pressure to which the growth solutions are exposed in order to control the composition of the epitaxial layers.

In the past, methods of growing epitaxial semiconductor layers have relied upon controlling the composition of the layers by temperature. Use of pressure to control the composition of the semiconductor epitaxial layers has the advantages of rapid and controllable variation and predictability. Specifically, as discussed in the specification at page 3, lines 22 to 29, the phase diagram as a function of pressure is monotonous and quasi-linear, in contrast with the phase diagram as a function of temperature which is complicated and non-monotonous. Controlling composition by means of pressure variation allows direct and easy control in comparison with prior methods of growing semi-conductor epitaxial layers which have relied upon temperature variation.

Specifically, claim 1 defines a method in which the first epitaxial layer is compositionally graded by varying the pressure in the chamber during epitaxial growth of that layer. It would be extremely difficult to achieve compositional grading in any controlled manner solely by use of temperature.

According to claim 13, the use of varying pressure is applied to a system in which two or more epitaxial layers are grown on the same substrate, wherein variation is achieved by varying the pressure between the growth of the layers. Again, in comparison with the standard method of iterative growth in which there is only temperature variation between growth of the layers, rapid and controlled changes can be achieved. As discussed in the

specification at page 3, line 36, to page 4, line 6, this results in improved quality of the epitaxial layers.

Dugger discloses a method of growing single aluminum nitride crystals with calcium nitride as a solvent in a molten solution growth of bulk aluminum nitride crystals. After melting aluminum nitride into a calcium nitride solvent, the temperature is lowered to induce supersaturation, whereby aluminum nitride single crystals will then precipitate out from the solution. Mentioned in the background is "degree of supersaturation can be changed by other means, such as evaporation of the solvent, or by changes in the pressure of the solution. The conventional way of influencing supersaturation in solution growth is by change of the solution temperature." (Column 3, line 16 to line 21).

Despite the passing comment made by Dugger that the degree of supersaturation can be changed by changes in pressure of the solution, there was no further elaboration of the physical effect involved, merits of the method, nor referencing to any prior art. In fact, Dugger further went on to utilize the temperature variation effect for the bulk aluminum nitride crystal growth. This is not an enabling disclosure.

More importantly, the method disclosed by Dugger is for the <u>three-dimensional</u> growth of bulk single crystals, which is very different from the present method of <u>two-dimensional</u> thin film <u>epitaxial</u> growth on top of a substrate. For thin film epitaxial growth, material composition control of the film in terms of lattice matching to the substrate is very important to obtain good quality films.

Presently, commercial crystalline substrates are grown in an ingot form via techniques such as LEC (Liquid Encapsulated Czochralski), VCZ (Vapor Pressure Controlled Czochralski), VGF (vertical gradient freeze), VB (Vertical Bridgeman) and HB (Horizontal Bridgeman) methods. In none of these bulk three-dimensional crystal techniques is the pressure varied during the growth process. More importantly, none of these bulk crystal growth techniques are used for epitaxial layer growth. Molecular beam epitaxy (MBE), metalorganic chemical vapor epitaxy (MOCVD) and liquid phase epitaxy (LPE) techniques for thin epitaxial layer growth are based on different concepts and none of them uses a varying pressure. Consequently, it is not correct to link the three-dimensional bulk crystal growth of Dugger with two-dimensional epitaxial growth of LPE. It is emphasized that pressure-varying epitaxial growth technique is not obvious; this fact can be clearly demonstrated by the absence of any epitaxial growth technique based on this concept existing even now.

Thus even if Dugger is somehow combined with Bernardi or Hsieh the result is not the present invention. Hence the rejection of claims 1, 2, 5 and 9 or claims 1 and 8-11 under 35 USC 103 on these combination of references should be withdrawn.

Similarly, the remaining references fail to show the present invention. Cook, for example, shows multiple layers, but not to vary the pressure for the different layers.

Liao discloses a method of preparing a composite solid particle, whereby particles are attached or stick onto surface of solid particle as a core. Subsequently, crystals of fine particle component are allowed to grow on core-fine particle combination with attached fine particles acting as crystal nuclei (in this

manner, fine particles are firmly fixed onto the core particle). Various crystal growth methods are quoted, and "in liquid-phase growing method, a crystal is allowed to grow from a solution obtained by "cooling a solution, evaporating a solvent, or applying a pressure to a solution, or such reactions as solid-liquid, liquid-liquid or vapor liquid reaction" [para 0026]. However, it should be noted that Liao crystal growth method here is <u>not about epitaxial thin film growth over a planar substrate</u>. In addition, the fine particles in Liao's method refer to "hydroxides halides, carbonates, sulphates, nitrates, phosphates, hydrogenphosphates and silicates of various metals [para 0020], and these materials are <u>not semiconductors</u>. Liao's fine particles acting as crystal nuclei in subsequent crystal growth are in a powder form, <u>not crystalline</u> and are attached to the core particle without any crystalline order. Consequently, this prior art cannot be considered to be of any relevance to the present invention.

Liao's method concerns growth of fine particle crystal growth onto fine particles attached to another larger core particle. This is not planal epitaxial growth over substrates, and the materials described are not semiconductors. It is not obvious that this bulk crystal growth based on fine particles of Liao can be related to liquid phase based epitaxial layer growth.

Claim 1 recites "…<u>compositionally</u> grading the first <u>epitaxial</u> layer by varying the pressure…". Claim 13 recites "…varying the pressure…between growth of the first <u>epitaxial</u> layer…to <u>affect the growth</u> of the at least one <u>further epitaxial</u> layer." This is not remotely shown in any reference.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are

clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge $110.00 for payment for one month extension of time and any other fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

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